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DETECTING COMPTON THICK AGN WITH IXO

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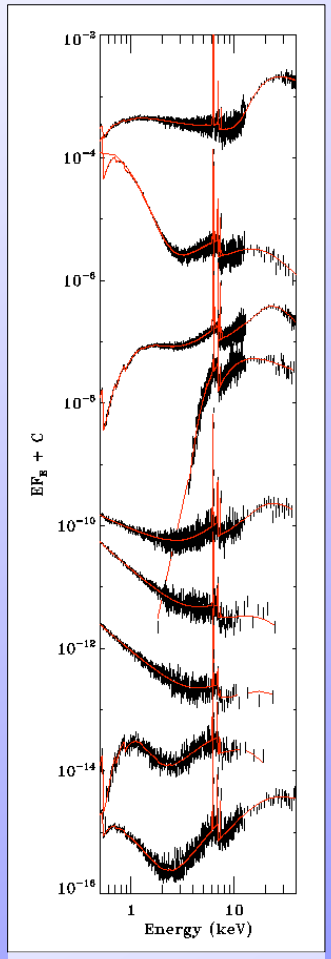


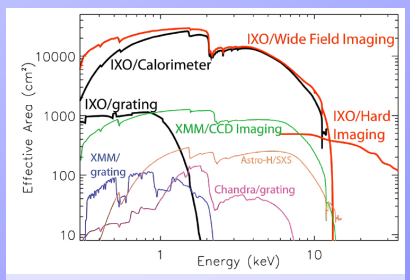
Fig. 1. 10-ks simulated IXO (WFI+HXI) spectra of 9 local Compton thick AGN. Observed data taken from Suzaku observations.

Abstract

We present an analysis on the capabilities of IXO to detect and identify high redshift Compton thick AGN, and compare these to hard X-ray imaging missions such as NuSTAR. This capability is important for one of the main science goals of IXO, that is, to study the growth of super-massive black holes across cosmic time. We use a dataset of local CT AGN from Suzaku observations to conduct this study. We show that IXO will uncover much of the population of heavily obscured AGN at z=1 in modest exposures (~100 ks). We determine that IXO will be able to spectroscopically identify CT AGN down to 2-10 keV fluxes of ~1.3×10^{-15} ergs cm^{-2} s^{-1} and will therefore explore a larger detection parameter space than NuSTAR for these sources.

INTRODUCTION:

One of the main science goals of the International X-ray Observatory (IXO) will be to study the growth of super-massive black holes across cosmic time. A key requirement for this is to be able to detect obscured accretion, particularly with Compton thick obscuration, at high-z, much of which is likely to be missing from our current surveys (Gilli, et al. 2007). Compton thick active galactic nuclei (CT AGN) are identified either below rest-frame 10 keV by a flat 'reflection' spectrum with an intense iron Ka line, or above 10 keV where the photo-electric absorption cut-off and the direct transmitted spectrum can be observed. IXO will observe both spectral regimes with its Wide Field Imager (WFI) and its Hard X-ray Imager (HXI). The sensitivities of these instruments, including with respect to each other, are important factors in considering this science goal.



Effective area plot of IXO's various instruments compared to present day observatories.

LOCAL CT AGN X-RAY DATA

We have compiled a dataset of Suzaku observations of local CT and heavily obscured (N_H>$10^{23.5}$ cm^{-2}) AGN in order to study their 2-40 keV X-ray spectral properties, and thus study how well IXO will detect these at a given redshift. These sources include NGC 5728, Mrk 3, NGC 1068, NGC 4945, Circinus, NGC 3281, NGC 2273, NGC 1386, NGC 7582, ESO323-G32, NGC 5643, NGC 5135, NGC 3393, SWIFT J0601.9-8636 and SWIFT J0138.6-4001. We have fitted models to these data which include reflection from optically thick material with self consistent Fe Kα emission (pexmon, Nandra, et al. 2007) and X-ray transmission through heavily obscuring material, also including Fe Kα emission (trans, Brightman & Nandra. In prep.).

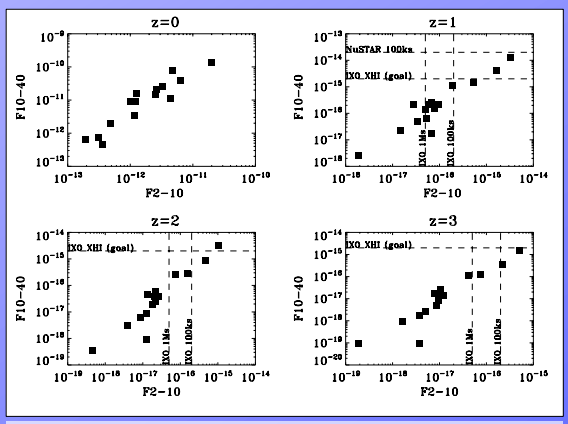


Fig. 2. 10-40 keV flux versus 2-10 keV flux (ergs cm^{-2} s^{-1}) for local Compton thick AGN with Suzaku spectra, and how they would appear at z=1,2,3. IXO 100-ks and 1-Ms sensitivity limits are marked, as is the NuSTAR 100-ks sensitivity limit. IXO will detect CT AGN an order of magnitude fainter at z=1 than NuSTAR.

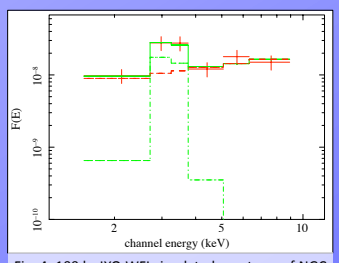


Fig. 4. 100 ks IXO WFI simulated spectrum of NGC 5728 at z=1 (F2-10=1.3×10^{-15} ergs cm^{-2} s^{-1}). The flat spectrum (Γ=-0.48) and intense Fe Kα line (EW=1.65 keV, detected at >99% confidence) unambiguously identify this source as being Compton thick.

IXO OBSERVATIONS OF CT AGN

Fig. 1 shows examples of 10 ks simulated spectra from IXO WFI +HXI for nine of our sample of CT AGN. Fig. 2 plots the observed frame 10-40 keV fluxes against the 2-10 keV fluxes for these objects, and how they would appear at redshifts 1, 2 & 3. Also shown are the 2-10 keV detection limits for 100 ks and 1 Ms IXO WFI observations; and 10-40 keV detection limits for 100 ks NuSTAR and IXO HXI observations. NuSTAR (nuclear spectroscopic telescope array) is a NASA mission aiming for launch in 2011, and will image the hard X-ray sky, and aim to resolve the hard X-ray background. We show that in 100 ks, IXO will be able to detect CT AGN an order of magnitude fainter in the 2-10 keV band than NuSTAR will in the 10-40 keV band.

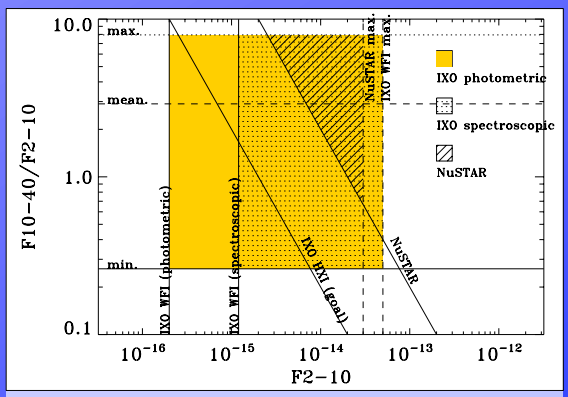


Fig. 3. CT AGN detection parameter space in 2-10 keV flux (ergs cm^{-2} s^{-1}) and 10-40 keV to 2-10 keV flux ratio at z=1 for IXO and NuSTAR. Lower limits are drawn with solid lines and upper limits are drawn with dashed lines. Max., mean and min. values of F10-40/F2-10 are from our sample of local CT AGN having been redshifted to z=1

DETECTING CT AGN AT z=1 IN FUTURE MISSIONS

Current deep X-ray surveys are probing the universe down to flux limits of ~10^{-16} ergs cm^{-2} s^{-1} in the 2-8 keV band (e.g 2 Ms CDF-N, Alexander, et al. 2003). IXO will reach these limits in 100 ks. In Fig. 3 we explore the CT AGN detection parameter space for IXO and NuSTAR for sources at z=1. This shows the 10-40 keV to 2-10 keV flux ratio against the 2-10 keV flux parameter space. The 'max', 'mean' and 'min' values for F10-40/F2-10 come from our local CT AGN dataset redshifted to z=1. We have determined that IXO can detect and spectroscopically identify CT AGN down to ~1.3×10^{-15} ergs cm^{-2} s^{-1} by the measurement of a flat power-law spectrum with an intense Fe Ka line (detected at >99% confidence, Fig. 4). The upper limits in the 2-10 keV flux parameter space are calculated from logN-logS relations (Brunner, et al. 2008), as the maximum flux at which one would expect to detect one AGN in a single pointing. The IXO maximum flux is therefore greater than for NuSTAR owing to a larger field of view. We illustrate clearly here that IXO will explore a greater CT AGN parameter space than NuSTAR and other such hard X-ray missions owing to very sensitive measurements in the 2-10 keV band, rather than in the 10-40 keV band. We do note however, that 10-40 keV observations are still important for determining the intrinsic power of heavily obscured AGN.

CONCLUSIONS

- IXO will uncover much of the z=1 CT AGN population and will be able to explore a larger CT AGN parameter space at this redshift than imaging hard X-ray missions due to very sensitive measurements in the 2-10 keV band.
- This will strengthen IXO's position to achieve its goal to study the growth of super-massive black holes out to high redshift.

REFERENCES

Alexander, D. M., et al. 2003. AJ, 126, 539; Brunner, H., et al. 2008. A&A, 479, 283; Gilli, R., et al. 2007. A&A, 463, 79; Nandra, K., et al. 2007. MNRAS, 382, 194